# CONTINUUM TOPOLOGY DESIGN OF HINGE-FREE COMPLIANT MECHANISMS

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Because of their diminutive size, MEMS are typically fabricated as monolithic continuum structures without any pinned or hinged joints. Many classes of MEMS are thus intended to function as *compliant mechanisms*, or mechanical systems that gain desired output motion in response to input loading primarily by means of distributed elastic deformation of the system. In this sense, these MEMS can differ quite markedly from large-scale mechanical systems that gain output motions primarily by rigid body translations and rotations. In an ideal sense MEMS based on *compliant mechanisms* are intended to function as hinge-free continuum structures.

In recent years, a fair amount of research has been published on application of continuum topology optimization to design of compliant mechanisms. Although mechanical systems in such design frameworks are frequently modeled with continuum methods, the combined analysis-design methodologies can often yield designs with *de facto* hinges. Such *de facto* hinges are regions of highly concentrated deformation and rotation in the mechanism that are artifacts of the underlying numerical modeling methods. The *de facto* hinges are undesirable in material layout design of compliant mechanisms for at least two reasons: (1) they are generally characterized by discontinuity of the basic structural material across the hinge-region; and (2) when approximated and fabricated as very slender bridges of structural material, the bridging material can be subjected to excessive stresses/deformations, with total mechanism failure occurring after just a few loading cycles.

In the proposed presentation, a number of strategies for achieving hinge-free compliant mechanism designs will be discussed and evaluated. Together with appropriate selection of a design objective, the primary tool used in the proposed strategies is application of resistive springs with properly selected stiffnesses to both the input and output ports of the mechanism being designed. The techniques to be presented appear very effective in that: (1) the resulting layout designs feature well distributed elastic deformation with no *de facto* hinges; (2) the computed efficiency characteristics of the mechanisms are competitive with those of hinged mechanisms. Insights on why the proposed design formulations are effective will be offered.